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# E907 RICH ODH Analysis

The E907 RICH Vessel has an internal volume of 1,500 ft$^3$. The vessel will be purged for several volume changes with carbon dioxide (specific gravity = 1.5) and then sealed with its contents at atmospheric pressure. The vessel is located in MC7. Grating in the floor of MC7, could allow a heavier than air gas to flow down to M Bottom which lies below MC7.

Based on FNAL drawings, the volume of MC7 is about 90,600 ft$^3$ while the volume of M Bottom is 31,500 ft$^3$. For this ODH analysis, only M Bottom will be considered because its volume is about 1/3 that of MC7. Thus if the E907 RICH cannot create an ODH hazard in M Bottom, MC7 is also safe.

Two scenarios are considered: (1) The rupture of one of the thin windows on the RICH and the subsequent venting of 1500 ft$^3$ of a heavier than air gas. (2) An error during filling which results in the $CO_2$ being vented into the MC7 experimental hall and then falling to M Bottom. The vessel will be filled with two “cans” of cryogenic $CO_2$ manifolded together. Each can contains about 3,300 ft$^3$ of gas. A temporary exhaust line will be run outside the MC7 enclosure to vent the $CO_2$ outside.

Considering the first scenario, if the 31.500 ft$^3$ of air in M Bottom is partially displaced by 1,500 ft$^3$ of $CO_2$ during a window rupture, then the remaining atmosphere is 30,000 ft$^3$ of Air and 1,500 ft$^3$ of $CO_2$. The amount of oxygen is reduced to 0.21 x 30,000 = 6,300 ft$^3$ $O_2$. Thus $O_2$ is 6,300 / 31,500 x 100 = 20.0 % of the atmosphere. The partial pressure of oxygen ($PO_2$) is then 0.200 x 740 mm Hg = 148.00 mm Hg. This does not create an ODH atmosphere.

If the 31.500 ft$^3$ of air in M Bottom is partially displaced by 6,600 ft$^3$ of $CO_2$ during a window rupture, then the remaining atmosphere is 24,900 ft$^3$ of Air and 6,600 ft$^3$ of $CO_2$. The amount of oxygen is reduced to 0.21 x 24,900 = 5,229 ft$^3$ $O_2$. Thus $O_2$ is 5,229 / 31,500 x 100 = 16.6 % of the atmosphere. The partial pressure of oxygen ($PO_2$) is then 0.166 x 740 mm Hg = 122.84 mm Hg.

According to ES&H 5064TA, the oxygen deficiency is defined as

$$\Phi = \sum_{i=1}^{n} P_i F_i$$

where $P_i$ is the expected rate of the $i^{th}$ event (per hour) and $F_i$ is the fatality factor for the $i^{th}$ event. $F_i$ is equal to

$$F_i = 10^{\left(6.5 - \frac{PO_2}{10}\right)} = 10^{\left(6.5 - \frac{122.84}{10}\right)} = 1.644 \times 10^{-6}$$

for the emptying of 2 cans of $CO_2$ into M Bottom.

The possible failures that would lead to the entire $CO_2$ can contents being emptied into M Bottom are a pipe rupture, $P_i$ = 3 x $10^{-6}$, or a general error of human omission such as disconnecting a fitting without isolating the supply, $P_i$ = $10^{-2}$. The supply piping is at a nominal pressure of 35 psi. Thus any human error leading to a discharge of $CO_2$ on the supply side into the room would be easily audible alerting the operator to the error. The discharge of the temporary exhaust will be securely fastened outside. It will also be labeled, stating that the point of discharge is to never be inside MC7.

The ODH fatality rate for a worst case scenario of emptying the 2 $CO_2$ cans into M Bottom due to a human error is then

$$\phi = \sum_{i=1}^{n} \left(10^{-2}\right)\left(1.644 \times 10^{-6}\right) = 1.644 \times 10^{-8}$$

which is less than $10^{-7}$ leading to M Bottom being classified as ODH Class Zero. MC7 is also and ODH Class Zero area with respect to the RICH because its volume is 3 times that of M Bottom.